THE ARGONNE INCINERATOR PROGRAM

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The basic program for the investigation of the operation of the Argonne Active Waste Incinerator has been completed, and the two primary objectives of this program have been successfully accomplished. They are:

First, to design and construct an incinerator which would safely and economically reduce the volume of combustible radioactive waste that is produced at Argonne National Laboratory. The incinerator's capacity of 100 cubic feet of normal wastes per 8-hour day is more than ample to handle the daily accumulation of wastes. The radioactivity of the exhaust gas from the incinerator has, under normal combustion conditions, been consistently below the exhaust gas tolerance specified by Health Physics and has in most cases contained less immediately measured activity than that found in normal surrounding atmosphere.

Second, to determine and make the modifications in the equipment and flowsheet that were necessary to obtain maximum efficiency throughout the system. These modifications were the result of the data obtained in the experimental phase of this program and have resulted in a 50 per cent increase in combustion rate and in an increase of A.E.C. filter life from 6 hours per filter to more than 60 hours per filter. The maximum over-all decontamination factor from feed to exhaust gas for the present operating conditions is 2 to 3×10^7.

As shown by the over-all decontamination factors and by the fact that the effluent exhaust gas contains less than the natural activity of the surrounding atmosphere, the incinerator system is able to handle higher levels of activity than used in those runs to which activity was added (maximum of about 10^{11} disint./(min.)(cu.ft.) since the effluent gas from these high level runs was a factor of 20 lower than tolerance. However, on the basis of the high background activity readings encountered during these runs, it is apparent that remote charging, ash removal, and additional shielding of the furnace cone and ash barrel would have to be provided to enable such levels of activity to be handled routinely.

The incinerator equipment consists of a type 330 stainless steel incinerator body in which the material is burned in the presence of excess air; a Schraier-Bartolucci vane plate washer, in which large particles of fly ash are removed; and a secondary scrubbing unit consisting of a Pease-Anthony Venturi and a Peabody scrubber in which the gas-borne radioactivity is normally reduced to within tolerance. Final clean-up is accomplished by an A.E.C. filter which is capable of removing radioactive particles to well within the minimum tolerance levels specified by this Laboratory's

Radiological Physics Division (2×10^3 beta disint./(min.)(cu.m.) and 70 alpha disint./(min.)(cu.m.)). When replacement is necessary, the loaded filter is burned in the furnace. From the filter, the gases are drawn through a positive displacement blower which moves the gas stream on to the discharge stack on the roof. The ash resulting from combustion falls through a grate system and settles through water located in the cone in the base of the furnace into a canvas bag filter inside of a stainless steel drum. The bag and its contents are removed from the system, dewatered, and then stored.

Sampling of the gas stream to determine the efficiency of each piece of equipment was carried out in two ways. The first method was based on the total amount of activity entering and leaving each unit. The second method was based on the total amount of particles (based on weight) entering and leaving a unit. Experimental results have shown that these two methods produce nearly equal results, at least in the less-than-2 μ particle size range.

The gas stream was also monitored after it passed through the final unit of the cleaning train (A.E.C. filter). This monitoring, based on radioactive counting of particulate matter, helps to insure safe operation of the incinerator with respect to the total amount of radioactivity discharged to the atmosphere.

In cases where the gas temperature was too high (above 200°F) to allow use of cellulose filter paper (Watman #44), a special fiber glass filter was used. The only sample point where this media is necessary is prior to the Schreier-Bartolucci scrubber. Here, in addition to high temperatures, a heavy particle loading is encountered. In order to be on a comparable basis, both influent and effluent gas samples around the Schreier-Bartolucci scrubber were taken with the same media.

Isokenetic samples were taken with a sample probe or head which was inserted directly into the gas duct through a 2-inch opening. Stairmand discs were used prior to each sample point.

After the sample has been taken, the filter media was removed and the radioactive count determined by use of Bradley Proportional Counters. The low level samples (less than 1×10^4 beta ct./min. per paper) were counted by means of PC-2 counters and the high level samples (greater than 1×10^4 beta ct./min. per paper) were counted in PC-1 counters. The counting time varied from 1 to 10 minutes depending on activity level. Both counters have 62 per cent yield.

For weight determinations, the sample medium was dried and weighed prior to and following the sampling. Both weight efficiencies and activity efficiencies can be determined on each sample. Efficiencies are based on the influent and effluent particulate concentration in the gas at each unit of the scrubbing train. The experimental program that was carried out investigated the major operating variables of the gas cleaning train. The salient results obtained from this investigation are as follows:

The decontamination factors produced by the furnace itself varied from 150 to 300. It should be noted that this decontamination factor is significantly different from that previously reported by KAPL (about 2000). Private communications indicate that the originally reported figure of 2000 was in error by a factor of 10, and the two sites are in agreement that 200 is a realistic value for the furnace decontamination factor.

As it was not feasible to sample the gas stream between the Pease-Anthony Venturi scrubber and the Peabody scrubber, the radioactivity removal efficiency was determined around the Pease-Anthony Venturi-Peabody scrubber couple at a constant water temperature and flow rate to the Peabody scrubber.

The scrub solution to gas ratio in the Venturi was varied between 4.7 and 45.6 gal./min. per 1000 cu.ft./min. The most effective flow ratio was about 20 gallons of scrub solution per 1000 cubic feet of gas.

The efficiency of the Venturi is indirectly proportional to temperature of the scrub solution over the range of 64°F. to 148°F.

The use of steam injection to enlarge the particles by means of the condensation nuclei principle was also investigated. Steam was introduced into the duct leading to the Pease-Anthony scrubber about 12 inches upstream from the Venturi throat.

In general, it was found that for a given Venturi scrub solution temperature, particle removal efficiency was about 50 per cent greater with steam injection than without steam up to temperatures at which efficiency fell off rapidly with no steam (about 140 to 110°F., respectively, with and without scrub solution in the Peabody scrubber). Above these temperatures, removal efficiency with steam injection decreased only slowly as the scrub temperature was further increased compared to a rapid decrease in efficiency in the absence of steam.

As long as the plates in the Peabody scrubber are kept covered with scrub solution, neither the scrub solution temperature or rate affects the efficiency of this unit between 100°F to 145°F and 2.5 to 7.0 gal./min.

The efficiency of the Peabody scrubber is proportional to the number of wet plates between zero and three plates; the addition of a fourth wetted plate does not appear to increase the efficiency of this unit appreciably.

It appears that the efficiency of the Schreier-Bartolucci scrubber is dependent upon the nature or size of the particulate being fed to it. The efficiencies varied from 25 per cent to 75 per cent depending upon the type of material being burned.

Very little experimental work has been done to determine the overall efficiency of the A.E.C. filter since A. D. Little Company, who designed the filter, has determined that it is 99.9% per cent efficient on 0.3 to 1 micron sized particulate. This corresponds to minimum decontamination factor of 1×10^3.

The efficiency of the filter was checked during one of the high activity level runs, and an average decontamination value of 2.6×10^3 was obtained. This value corresponds to an efficiency of 99.96 per cent.

The over-all decontamination factor for the entire system is proportional to the level of activity in the feed and reaches a maximum value of 2 to 3×10^7 where it remains constant.

A summary of decontamination achieved by the incinerator components is:

Component	Decontamination Factor
Furnace	2.2×10^2
Schreier-Bartolucci Scrubber	1.2
Pease-Anthony Venturi Scrubber	50
A.E.C. Filter	2.6×10^3
Over-all	3.4×10^7

In order to test the efficiency of the gas scrubbing train on atmospheric dust, two experiments were conducted in which air from outside of the building was drawn through the gas train. The conditions were the same as during a normal combustion period except that no material was burned. The results are as follows:

	Air Intake, disint./(min.)(cu.m.)	Air Exhaust disint./(min.)(cu.m.)
Run 1	$\alpha = 73$	Background of Counter
	$\beta = 219$	40
Run 2	$\alpha = 393$	2.8
	$\beta = 863$	14

It is apparent, since the exhaust stack gas normally contains less activity than the natural radioactivity present in the surrounding atmosphere, that considerably lower efficiency could be tolerated throughout the system. The main value of increasing the over-all efficiency is in decreasing the "dust" load to the A.E.C. filter, thereby increasing its operating life. The experimental work on the Venturi-Peabody couple produced data which enabled the filter life to be extended from one 8-hour day to ten 8-hour days. This over-all increase has reduced the cost of the filter from \$40.00/day to \$4.00/day.

The cost of incineration of active wastes based on 8-hour operation, and 24-hour operation are as follows:

	8-Hour	24-Hour
Direct Operating Costs	$1.78/cu.ft.	$1.38/cu.ft.
Depreciation of Building and Equipment	$0.90/cu.ft.	$0.22/cu.ft.
TOTAL	$2.68/cu.ft.	$1.60/cu.ft.

These values are direct out of pocket costs based on actual operating figures.

At the time the incinerator program was originally set up there were two primary motivations to the program. One was to provide a means of safely reducing the bulk of the dry active waste for temporary storage at this site; since at that time no site had been established as either an interim or long term National Burial Ground. The other was to pilot plant the process of incineration to obtain cost and operating data, since there was at the time widespread and general interest in incineration as a unit operation.

The pilot program has been successfully completed and reported in detail in ANL-5067. Oak Ridge National Laboratory has recently been willing to accept shipment of all the solid waste from this Laboratory and indications are that the arrangement can be continued for some time.

A cost analysis of the first shipment of waste to ORNL indicated that the savings to be realized by incineration of the combustible portion of the waste were only about ten cents/cubic foot over shipping all of the waste as collected.

In view of the current man-power shortage and in light of the above facts, the incinerator program has been concluded and the equipment placed in standby condition.